THE DENVER ENGINEERING WORKS COMPANY

SHEPARD AND SEARING

BULLETIN NO. 1039

SEPTEMBER 1, 1908

RICHARDS PULSATOR CLASSIFIER

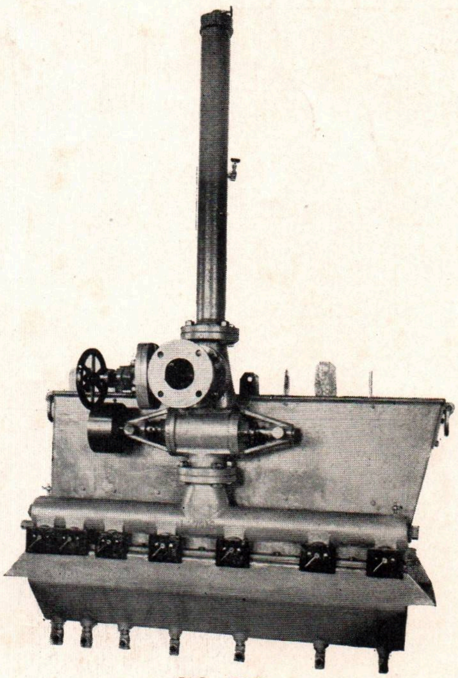


FIG. 753.

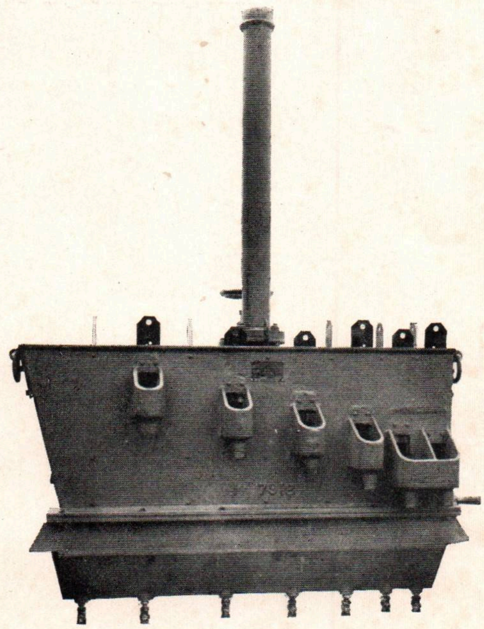


FIG. 743.

175-TON 6-COMPARTMENT RICHARDS PULSATOR CLASSIFIER.

The Richards Pulsator Classifier is patented in the United States and applications for patents have been made in all the principal foreign countries.

RICHARDS PULSATOR CLASSIFIER

The Richards Pulsator Classifier is the invention of Robert H. Richards, S.B., L.L.D., author of ''Ore Dressing.'' Those who have familiarized themselves with the technical side of ore concentration know that the hydraulic classification of ores has received Dr. Richards' special attention for many years past, as witnessed by the thorough exposition of the subject set forth in ''Ore Dressing'' and by the many papers thereupon which Dr. Richards has contributed to the technical press and to the ''Transactions of the American Institute of Mining Engineers.''

The Pulsator Classifier is the crowning result of an evolution in the form and application of hydraulic classifiers.

FUNCTION

Its function is the proper classification of crushed ores for subsequent treatment upon concentrating tables, or similar machinery.

RESULTS ACHIEVED

By its use the size of material successfully treated by concentrating tables is so increased as to make the table preferable to fine jigs; the capacity of the tables is tremendously increased over previous practice (in some cases more than doubled); and despite the increased capacity of the tables, the recovery effected thereby is greatly improved.

IMPORTANCE OF CLASSIFYING PULPS

It has been established beyond doubt that the work of concentrating tables treating a classified or sized feed is so superior, both in quantity and quality of work performed, to the work done when treating a ''natural'' or ''mixed'' feed, that neglecting to take advantage of the benefits to be derived therefrom is the most reprehensible mill practice. We refer anyone desiring further information on this point, to Dr. Richards' papers, ''The Wilfley Table,'' read before The American Institute of Mining Engineers, at the Toronto meeting, July, 1907, and at the New York meeting, February, 1908.

CLASSIFIER VERSUS SCREENS

The choice between the use of screens producing a sized feed and the use of classifiers producing a classified feed for the tables, is a much mooted question, each method having its particular advocates. It is, however, safe to say that the choice has been influenced principally by the performance of the machines employed, rather than by a difference between the recovery obtained with either perfectly sized or perfectly classified material.

SCREENS

The objections to screen sizing finely crushed pulp are mechanical. Everyone of milling experience knows the tremendous difficulty encountered in satisfactorily screen sizing below a relatively coarse mesh. The standard form of revolving screen when used with fine screen cloth is a never ending nuisance and source of trouble. The efficiency of such a screen is very low, requiring for any considerable ton-

nage a screen of vast proportions. The screen cloth "blinds," that is, the openings clog, requiring almost constant attention to effect any screening whatsoever. Numerous attempts have been made to overcome this trouble with various forms of shaking or bumping screens. In all of these latter forms the object is first to distribute the ore entirely over the screen cloth employed, and second to keep the screen cloth from blinding. It is most difficult to keep the shaking or bumping type of screen in repair, as all successful concentrating mills operate 24 hours a day, and the difficulty of keeping a machine which is shaking or bumping at the rate of from 200 to 400 strokes per minute in repair under such conditions can readily be appreciated, even by a layman. The wear on the screen cloth of these screens is also most excessive.

Again, any installation for screen sizing a finely crushed ore into several different products will be many times higher in first cost, and will occupy far more mill space than will a Richards Pulsator Classifier of equal capacity producing the same number of products.

IMPERFECTIONS IN PREVIOUS CLASSIFIERS

Before the advent of the Richards Pusator Classifier, hydraulic classifiers left much to be desired in their performance. The classifiers used to prepare ore for concentrating tables were of the Spitzkasten or pointed box type, or mechanical modifications thereof. The Spitzkasten or pointed box classifier is shown in Fig. 360.

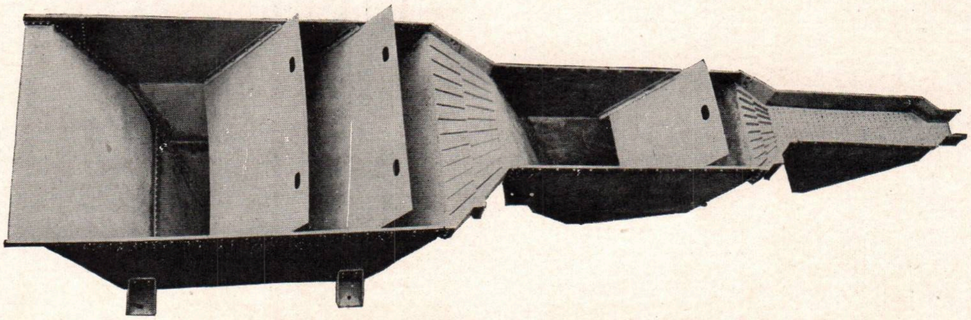


FIG. 360 THREE-COMPARTMENT SPITZKASTEN.

In this form of machine, classification is effected by a change in the velocity of the current of water carrying crushed ore. The pulp is fed to the small compartment shown at the right-hand side of Fig 360. The first compartment of the classifier is of greater area than the launder carrying the pulp, consequently a reduction in the velocity of the pulp current is effected, with the result that the heavier particles of ore settle to the bottom of the compartment whence they are drawn off for treatment. The next compartment of the classifier is of still larger area with a consequent further decrease in velocity of the pulp current, and a further settling of relatively heavy particles. This is continued until the desired number of products are obtained.

The use of even this early form of classifier is greatly to be preferred to the use of a mixed feed to tables, as a partial classification is effected. Nevertheless the machine has many faults. In the first place the machines are necessarily of considerable area, requiring a great deal of mill space. In the second place the heavier particles going to the bottom of the compartment, entrap and carry with them finer particles, thereby rendering the classification imperfect. In the third

place, fine free mineral particles have an affinity for larger particles, and cling to and discharge with the large particles of gangue, consequently when treated on the concentrating tables, they are washed free from the large gangue particles and lost in the table tailings. In the fourth place, whenever the material is drawn from the bottom of the Spitzkasten compartments, a downward suction takes place which momentarily partially, or wholly, destroys the classifying action of the machine. In the fifth place, it is a difficult matter to discharge the accumulation of settled ore at the bottom of compartments, as this tends to pack in and entirely close the discharge opening.

CHARACTERISTICS OF OUR MACHINE

The Richards Pulsator Classifier is a simple mechanical device, requiring little attention after it is once installed and adjusted for the work it is to perform. It occupies a very small area and very little head room, and, as we shall point out hereinafter, its operation overcomes all of the objections hitherto raised against hydraulic classifiers.

It is a remarkable machine in two respects; first, in its capacity as compared with its size when considered in comparison with previous forms of classifiers; second, in the quality of work it performs, that is, in the perfect classification which it effects.

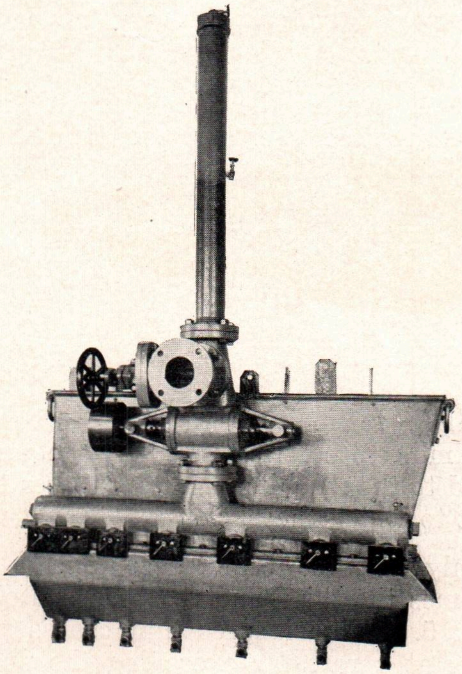


FIG. 753.

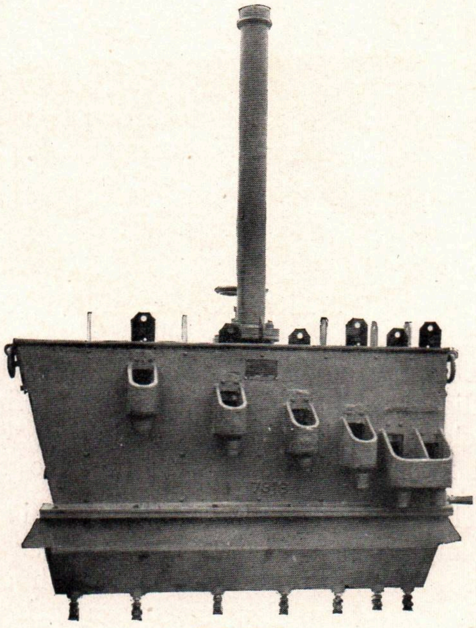


FIG. 743.

COMPARATIVE SIZE

The machine shown in Figs. 753 and 743 is a standard 4-inch, six-compartment Richards Pulsator Classifier. It has a capacity of from 150 to 200 tons of ore in a properly thickened pulp per 24 hours, which it delivers in six different classes. Standard Spitzkastens, per Fig. 360, are seldom used for more than four classes of product. One Spitzkasten handling 150 tons of thickened pulp would be of prohibitive size and in practice two machines, each handling 75 tons per 24 hours, would be installed. Assuming that these two Spitzkastens are set side by side, the comparison between the Richards Pulsator Classifier and the Spitzkasten is as follows:

FOR A DUTY OF 150 TONS PER 24 HOURS

	No. of Products	Total Weight	Length Overall	Height Overall	Maximum Width Overall	Maximum Fall; Feed to Lowest Delivery Point
Richards Pulsator Classifier	6	2,000 lbs.	6 ft.	3½ ft.	2⅜ ft.	2 ft.
Spitzkasten	4	17,400 lbs.	40 ft.	9 ft.	25 ft.	9¾ ft.

In the above figures the height of the air column on the Richards Pulsator Classifier is not included, since this portion of the machine occupies a space which would otherwise be unused.

IMPROVEMENT IN CLASSIFICATION

The classification effected by the Richards Pulsator Classifier is so perfect that the performance of concentrating tables is improved thereby in several ways, any one of which alone renders the machine a most important contribution to the art of ore dressing.

The classifying current maintains a constant agitation of the ore from the moment the ore enters the machine until it is discharged as a classified product, hence groups of particles are broken up, insuring that each class of material will be delivered from the proper spigot. In both the inverted and direct forms the lighter, finer particles are liberated from the heavier particles by the agitation, and in the inverted form the velocity of the classifying current in the first compartments is not sufficient to lift the heavier particles, while in the direct form the velocity of the classifying current in the first compartments is so great that the finer particles cannot settle against it, hence the second objection to the Spitzkasten mentioned on page 4 is entirely overcome.

SEPARATION OF FINE FREE MINERAL FROM GANGUE

This thorough agitation of the ore from the moment it enters the machine until it is discharged therefrom, washes the fine free mineral particles off the large gangue particles to which they are clinging when fed to the machine, and discharges these small mineral particles with the fine product to which they belong.

The Richards Pulsator Classifier is the only machine which accomplishes this with any degree of certainty and thus overcomes the third and most serious objection to the Spitzkasten, as set forth on page 5. This insures that coarse products may be treated upon concentrating tables at a rate far exceeding the normal capacity of the tables without washing fine free mineral particles into the tailings.

FREE AND CONTINUOUS DISCHARGE

A perusal of the description of the machine, hereinafter given, will show that the discharge of the product is continuous in action and of such a nature as to entirely overcome the fourth and fifth objections to the Spitzkasten.

The Richards Pulsator Classifier, therefore, overcomes not only one or two, but all of the difficulties hitherto encountered in hydraulic classification.

QUALITY OF WORK PERFORMED

Practically all of the previous forms of hydraulic classifiers are "free settling" in their nature, that is, the particles settle freely without being hindered by other particles. Now the Richards Pulsator Classifier classifies by "hindered settling"; that is, with the particles crowded together in a mass, jostling and crowding each other, and continually agitated by the action of the machine. In all hydraulic classifiers, if the ore be so crushed as to free the mineral entirely from its matrix, (possible, by the way, with only a very few ores wherein the mineral is very coarsely disseminated) the product of the classifier, if the classification be perfect, will consist of small particles of the heavier elements of the ore, discharged together with larger particles of the lighter elements of the ore. Herein "classification" differs from "sizing." The ratio of the diameters of the different particles in such a product has been definitely established by test and experiment.

INCREASED RATIO OF EQUAL SETTLING GRAINS

These tests have established that under perfect free settling conditions, an ore consisting of galena and quartz crushed to entirely liberate the galena from the quartz, will result in a classified product from any one compartment, wherein the particles of quartz have about 3.5 times the diameter of the particles of galena. Treating a similar ore in the Richards Pulsator Classifier, the particle of quartz will be about 6.5 times the diameter of the particle of galena.

Therefore, on an ore wherein it is possible so to crush the ore as entirely to liberate the mineral, the Richards Pulsator Classifier will produce a product which can be concentrated by screens.

The increase in ratio of diameters also greatly improves the action of concentrating tables. It would require an exhaustive explanation of the theory and action of concentrating tables in order fully to explain this in this bulletin, and we will therefore not attempt it, but will merely ask those familiar with the operation of concentrating tables to consider how readily the large particles of light gangue will be washed aside leaving undisturbed the small and heavy mineral. A moment's consideration of this will clearly show one of the reasons why the performance of concentrating tables treating pulp classified by the Richards Pulsator Classifier is so remarkable an improvement as hereinafter shown by the description of a plant wherein the Richards Pulsator Classifier is now employed.

RELATION TO RE-CRUSHING

In practice this effect is very marked in the finer sizes, but is relatively small in the coarser products because most ores carry mineral so finely disseminated that it is not wholly liberated from its gangue until crushed to a very fine size; in fact, very few ores can, under commercial operating conditions, be so finely crushed as to entirely free the mineral. The degree of crushing necessary to insure that final tailings will not carry recoverable values in the form of included grains is one of the most important points in successful ore dressing practice. Where ores carry both large and small particles of mineral—as is generally the case—good practice requires graded concentration, by jigs, coarse tables, fine tables, and slimers, with recrushing and subsequent reconcentration, of the tailings from the machines treating the coarser sizes.

Therefore the fact that the Richards Pulsator Classifier delivers a coarse product from which clinging particles of fine free mineral have been eliminated, is of great value, because if the jig, or table, tailings assay an appreciable amount of mineral it is a certainty that the mineral is still embedded in its gangue; that is, is in the form of an included grain, and the tailings must be recrushed in order to further extract the values. Conversely, the exact point in the system wherein the tailings may first be sent to waste is exactly established.

SCREENS AS ROUGH CONCENTRATORS

The increased ratio of equal settling grains effected by the Richards Pulsator is also of great value in the economical treatment of the finely crushed ores. When the ore is crushed so fine that the condition of an absolute liberation of mineral from gangue is approached, then a very close relationship between the size of the grain and its mineral content is established, and a fine screen can be used as a rough concentrator. Treating a copper ore wherein included grains are still found after the ore is finer than 150 mesh, the Richards Pulsator Classifier is fed with ore ranging from 2.5 mm. (5 mesh No. 13 wire, approximately) to zero, and the tables treating the fine product themselves produce middlings and tailings still high enough in copper to make further recovery advisable. These middlings and tailings are screened over a screen of very fine mesh and the oversize is sent to waste, while only the undersize is further treated. Were it not for the large size of the sparsely mineralized matter delivered with the small rich grains by the Richards Pulsator Classifier this partial concentration by screens could not be accomplished.

TABLES VERSUS FINE JIGS

Heretofore the coarsest material successfully treated by the reciprocating table has been pretty generally established at about 12 mesh, which with standard screen cloth made of No. 19 gauge wire, gives an opening of 0.042 inches, or 1.065 millimeters. Chiefly because the Richards Pulsator Classifier entirely eliminates fine free mineral from its coarser products, ore as coarse as 2.5 millimeters has been successfully treated on tables, when first classified by our machine. In our opinion, however, a mechanical difficulty, a too rapid wear of the table riffles, is apt to ensue when tables are treating 2.5 mm. material, and while we are warranted in claiming that the Richards Pulsator Classifier has more than doubled the size of particle successfully treated by the tables, we recommend that the classified product coarser than 8 mesh, No. 16 wire (1.57 mm.) be treated upon the Richards Pulsator Jig.

Because of the difficulties heretofore encountered in treatment of relatively coarse ore upon reciprocating tables, jigs have been preferred to tables for the concentration of material ranging between 10 mesh (1.34 mm.) and 14 mesh (0.915 mm.). Since the Richards Pulsator Classifier so radically improves the performance of the tables treating coarse material, both as to capacity and recovery, it is a certainty that the Richards Pulsator Classifier in connection with the reciprocating form of tables will soon entirely replace the fine jigs.

INCREASED CAPACITY OF TABLES

As hereinbefore stated, it is an acknowledged fact that concentrating tables do their best work when fed with a classified or sized feed. The perfect classification effected by the Richards Classifier results in an astonishing increase in table capacities, thus further proving the necessity of classification ahead of the tables. At one installation five reciprocating tables and one vanner handle 200 tons of ore, crushed to pass 2½ mm. per 24 hours. When one considers that the normal capacity of a reciprocating table has heretofore been considered as 15 tons per 24 hours, while vanner capacity has been considered 8 tons per 24 hours, the remarkable performance of this particular group of machines is appreciated.

IMPROVED RECOVERY

But perhaps the most excellent feature of the Richards Pulsator Classifier is that by its use at the installation mentioned in the preceding paragraph, the amount of mineral in the final tailings is almost exactly halved as against previous practice.

THE RICHARDS PULSATOR CLASSIFIER HAS ALREADY BEEN ADOPTED BY THE FOLLOWING WELL KNOWN COMPANIES:

Boston & Montana Cons. Copper & Silver Mining Co	Great Falls, Mont.
St. Joseph Lead Co	Flat River, Mo.
Tomboy Gold Mines Co., Ltd	Telluride, Colo.
Colusa-Parrot Mining & Smelting Co	Butte, Mont.
Federal Mining & Smelting Co	Wallace, Idaho.
The United Rico Mines Co.	Rico, Colo.
Henry E. Wood Ore Testing Co	Denver, Colo.
Evergreen Gold & Copper Mining Co	Apex, Colo.
Dan Gold Mining Co	Baker City, Oregon.
Copper Creek Mining Co	Copper Creek, Ariz.
Leadville District Milling Co	Leadville, Colo.
Old Hundred Mining Co	Silverton, Colo.
El Tiro Copper Co	Silverbell, Ariz.
F. C. Rutan	Hailey, Idaho.
Ray Consolidated Copper Co	Kelvin, Ariz.
Mexico Consolidated Mining & Smelting Co	San Pedro Guanacevi, Durango, Mexico.
Moctezuma Copper Co	Nacozari, Sonora, Mexico.

DESCRIPTION OF THE INVERTED TYPE

Referring to Fig. 0168, the hydraulic water is brought to the main gate valve, V. The pressure at which the hydraulic water should be delivered depends upon the size and specific gravity of the ore treated. A head of 30 ft. is required for copper ores carrying $2\frac{1}{2}$ mm. grains, or for galena ores carrying 2 mm. grains, while a head of 15 ft. will suffice for ores wherein the coarsest grains are 0.75 mm. in diameter (about 20 mesh). The hydraulic water then passes through the pulsating valve, B, by which the pulsating effect which characterizes the machine is obtained. A is an air chamber. Below the pulsating valve, B, is a manifold, M, which distributes the hydraulic water to each of the several compartments of the machine. Individual valves, W, control the hydraulic water of each compartment.

The hutch of the machine, H, is divided by transverse walls into the several compartments H^1, H^2, H^3, H^4, H^5, and H^6, as shown by the dotted lines in the "Elevation of Discharge Side," Fig. 0168. The hutch also extends under the feed spout, F.

The partition, "h," is common to each compartment of the hutch.

The hydraulic water runs from the manifold around "h" through the hutch, then up to the sieve, S, as indicated by the arrows in "Section on Line X-Y," Fig. 0168.

Referring to the "Elevation of Discharge Side" and the "Plan," Fig. 0168, it will be seen that the length of any hutch compartment and corresponding classifying compartment is greater than the length of any succeeding compartment, and that all compartments except the last classifying compartment C^6, are of the same width. Consequently the velocity of the pulsating hydraulic water at S^1 will be relatively low, while the velocity of the hydraulic water at S^6 will be relatively high, since the pressue at V is constant and W^1, etc., constitute inlets of equal area. A hutch, H^0, and sieve, S^0, are also provided for the feed hopper.

We therefore have at the screen level of the machine, S^0 to S^6, seven different ascending, pulsating columns of water, the column at S^1 being of low velocity, at S^2 of relatively higher velocity, at S^3 of still higher velocity, and so on to S^6, where the column of water has the highest velocity of the seven columns.

The six classifying compartments, C^1 to C^6, are divided from each other by transverse walls, which correspond with the division walls in the hutch. Each division wall of the classifying compartments is provided with an adjustable gate below which the ore passes from compartment to compartment.

The ore is introduced at F and falls to the sieve level, S^0, where it encounters a rising pulsating current of water which serves to agitate the ore, get it in partial suspension and prevent clogging of the feed hopper. From the feed hopper the ore passes below the gate F^1, where it encounters and is subject to the action of the slowly rising, pulsating current of hydraulic water in C^1. This current further agitates the ore, lifts out and raises to the discharge opening, O^1, the lightest, finest particles in the ore, whence they are discharged. Below the gate F^2 the ore feeds from classifying compartment C^1, on the sieve, S, to classifying compartment C^2, where, as explained above, it is subjected to a more swiftly rising, pulsating current of hydraulic water which continues the agitation set up in the feed hopper and compartment C^1, and lifts out of the ore bed the next heavier particles, which are raised to and discharged at O^2. This process is repeated successively in compartments C^3, C^4, C^5, and C^6. In the latter compartment only the heaviest par-

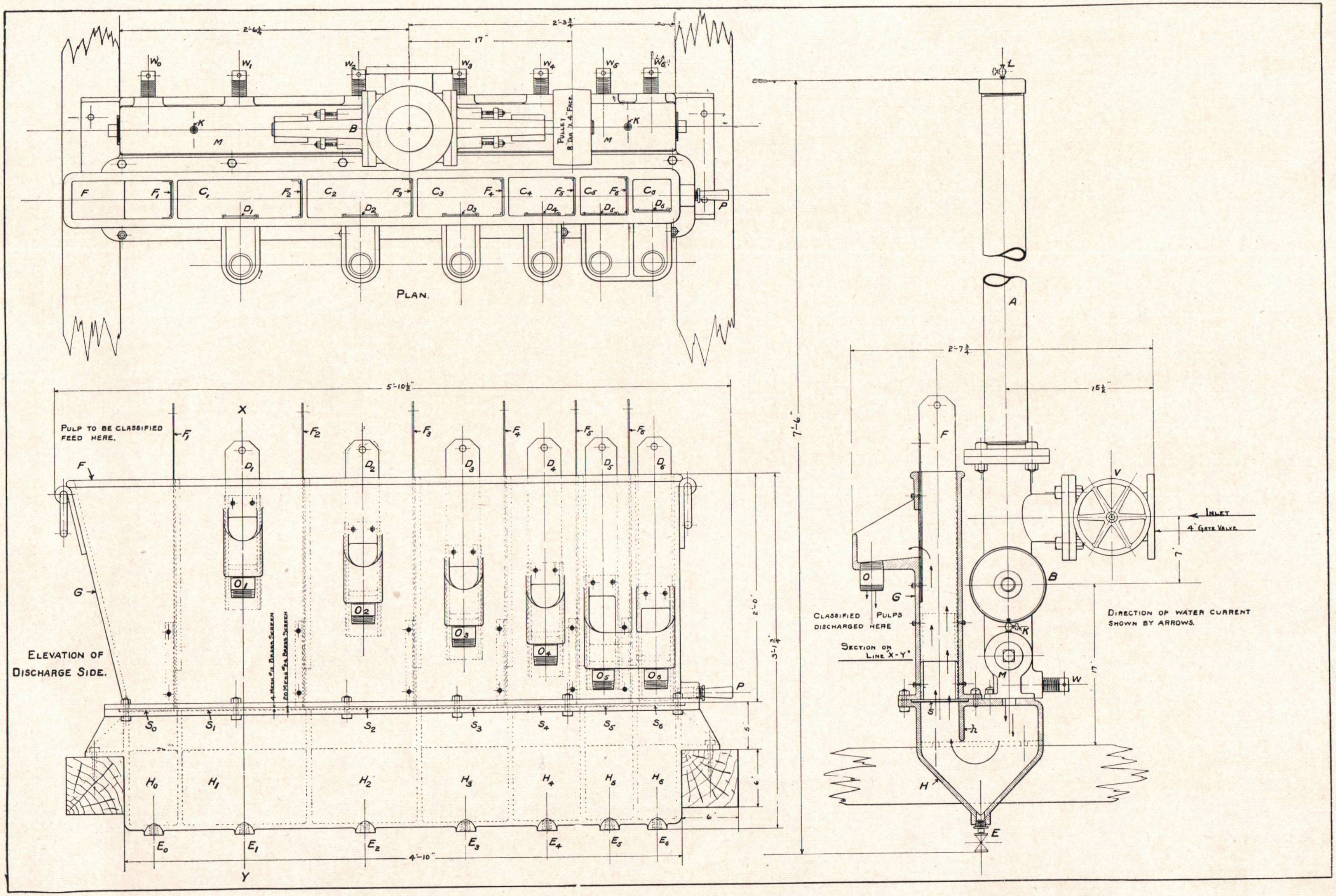


FIG. 0168. PLAN AND ELEVATION OF 200-TON RICHARDS PULSATOR CLASSIFIER, INVERTED TYPE.

ticles will have been left in the ore bed, and these are discharged from O_6. In event that the ore contains particularly heavy particles, the current in C_6 may not be sufficient to lift all of the ore to O_6, in which event the plug, P, is removed from its spigot. In the majority of cases where it is necessary to use the spigot, P, the discharge therefrom will be found to be excellent concentrates.

The openings, O, are the only discharge openings in the machine, and O_1 is considerably higher than O_6. Hence the water in the machine tends to flow towards O_6, thus washing the ore along the sieve, S, to the final discharge opening O_6, or P, as the case may be. Gates are provided for varying the height of the discharge openings, O, within wide limits.

Properly adjusted, the Richards Pulsator Classifier will discharge all the slimes in the ore from the first two discharge openings, O_1 and O_2.

The sieve, S, serves to support the bed of ore and has no part in the classification. Particles of free mineral of sufficient size to settle against the classifying current in the first one or two compartments, but finer than the mesh of S may occur in the feed, in which event they will sink to the bottom of the hutch whence they may be drawn off as a rich concentrate through the spigots shown. This, however, will rarely occur and in general the hutch need not be drained oftener than once a day.

APPLICATION OF THE INVERTED TYPE

The inverted type of classifier is the standard commercial form for mills where the classifier duty is in excess of 25 tons of ore per 24 hours, and where the feed to the classifier is practically continuous.

APPLICATION OF THE DIRECT TYPE

When the tonnage to be treated is less than 25 tons daily, or where, as in laboratories or ore testing plants, the amount of ore available is not sufficient to enable final adjustment until a large percentage of the material has passed the machine, we recommend the direct form of classifier.

DESCRIPTION OF THE DIRECT TYPE

The direct form differs from the inverted in that the hydraulic water of greatest velocity adjoins the feed spout, and the least velocity occurs in the final classifying compartment. The pulsation of the hydraulic water is accomplished in the same manner as upon the inverted type.

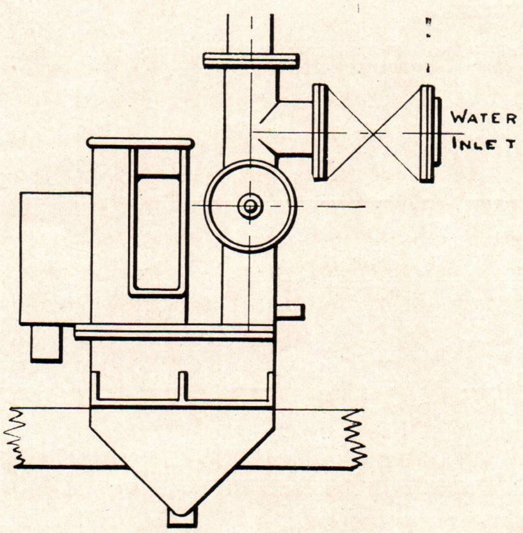


FIG. 0177. END ELEVATION RICHARDS PULSATOR CLASSIFIER, DIRECT TYPE.

Instead of being fed to the bottom of the classifying compartment, as in the inverted type, the ore is fed at the top of the classifying column and only the coarser, heavier grains will settle to the bottom thereof. Grains which will not settle in the first compartment overflow to the second compartment, which, in reverse of the method employed in the inverted type of machine, is of greater area than the first compartment. Obviously the velocity of the hydraulic water in the second compartment will be less than in the first compartment, and the material settling in the second compartment will be lighter and finer than the product of the first compartment. This process is repeated in successive compartments of increasing area until the desired number of classes is obtained.

At the bottom of each compartment is a side discharge opening through which the classified ore passes into an auxiliary compartment, whence it rises to height determined by adjustment of a discharge gate, through which it is discharged from the machine. The adjustment of the latter discharge gate determines the depth of the bed in the classifying compartments, and the ensuing relationship between the capacity of the machine and the steadiness of its performance.

SIZES AND DIMENSIONS

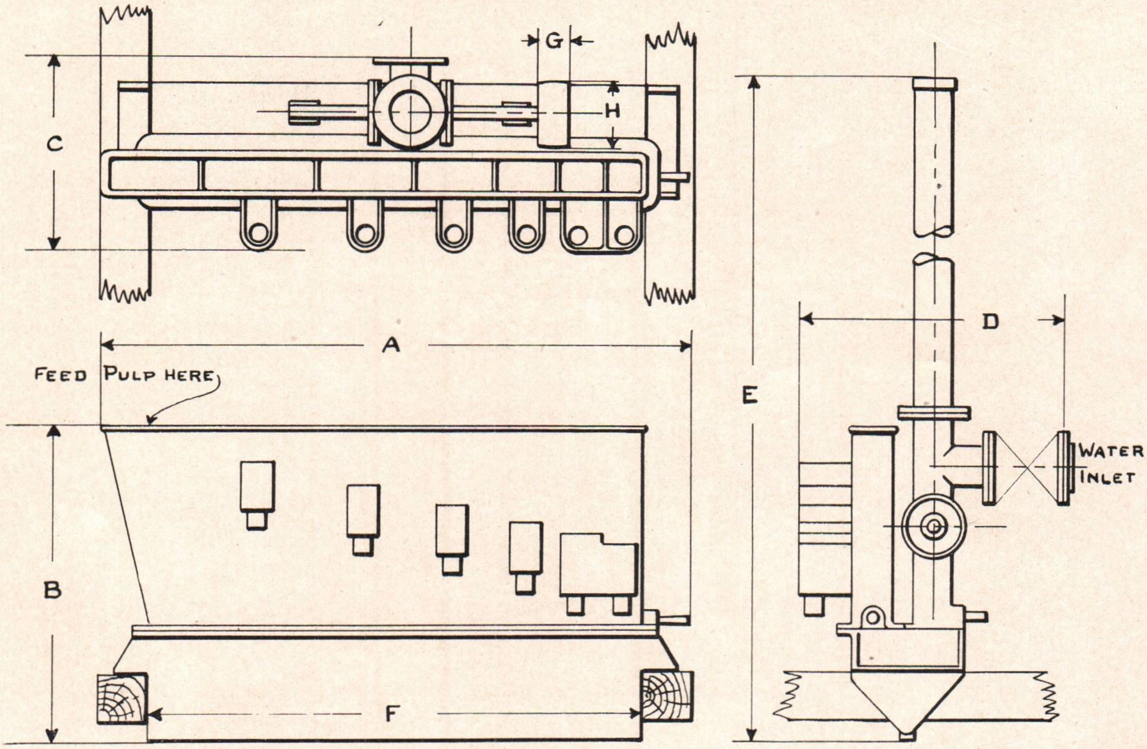


FIG. 0181.

TYPES AND SIZES

THE RICHARDS PULSATOR CLASSIFIER IS MADE IN THE FOLLOWING TYPES AND SIZES:

TYPE	SIZE	No. of Compartments	*Approximate Capacity in Tons per 24 Hours	DIMENSIONS—APPROXIMATE ONLY							
				A	B	C	D	E	F	G	H
Direct	2 in.	6	40	51	30	21	21	73	26⅝	1½	8
Inverted	2 in.	6	40	37	31	19	19	73	30¾	1½	8
Inverted	3 in.	6	100	53	35	21	27	90	43	3	8
Inverted	4 in.	6	175	70½	38	22¾	30¾	100	58	4	8

* = With pulp at a consistency of 3 parts water to 1 of ore, by volume.

Ore crushed to pass 2 mm.

RICHARDS PULSATOR JIG

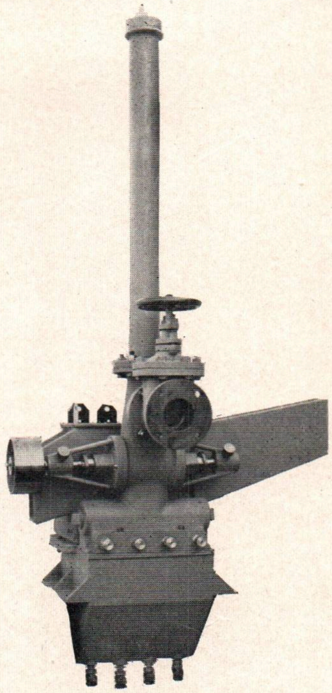


FIG. 746.

90-TON CAPACITY 4-COMPARTMENT RICHARDS PULSATOR JIG. EACH COMPARTMENT HAS ONLY 4x4 INCHES SCREEN SURFACE. THE ROTATING VALVE HAS TWO BEARINGS OUTSIDE THE STUFFING BOXES. ROTATING VALVE AND MANIFOLD COMBINED IN ONE CASTING. THE CASTING FORMING THE JIG COMPARTMENTS CAN BE SEPARATED FROM THE REST OF THE MACHINE TO EXPOSE THE SCREENS WITHOUT DISTURBING ANY OTHER PART OF THE APPARATUS.

TOTAL FLOOR SPACE OCCUPIED BY THIS MACHINE, INCLUDING FEED AND TAILINGS SPOUTS, 50 INCHES BY 26⅝ INCHES.

The Richards Pulsator Jig is similar in almost every respect to the ordinary Harz jig, except that by the use of a peculiar form of pulsating current, one square inch of screen surface can be made to do the work of 200 square inches of screen surface of the ordinary jig.

This remarkable invention is such an innovation in concentrating apparatus and the claims made for it are so extraordinary that those who have not seen the apparatus in actual operation will find it difficult to believe our assertions.

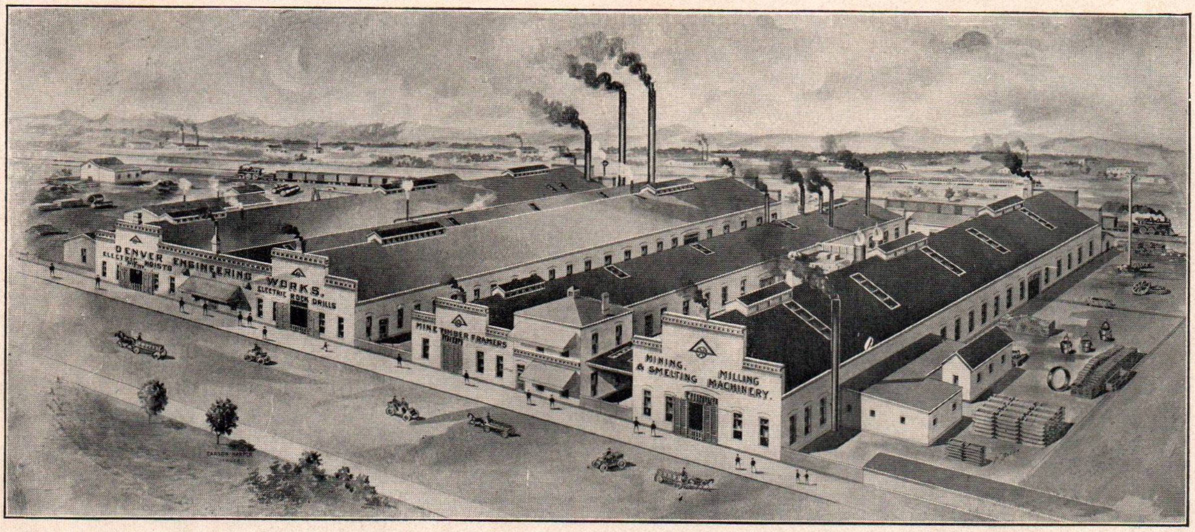
Our statements, however, have all been substantiated by actual trial in one of the largest copper concentrating mills in Montana. And further, after this company had experimented with this one machine, which was of ninety tons capacity, they ordered another jig of four hundred tons capacity, and both of these machines are now in operation at this mill.

TABLE OF COMPARISON FOR RICHARDS AND HARZ JIGS EACH HAVING CAPACITY OF 90 TONS PER DAY

Type of Machine	Number of Machines Required	Floor Space	Weight	Water	Number of Places to Lubricate	Horse Power	Screen Area
Richards . .	1 Single 4-Comp.	8 sq. ft.	1,500 lbs.	80,000 gals.	1	1¼	64 sq. ins.
Harz	3 Double 4-Comp.	530 sq. ft.	30,000 lbs.	425,000 gals.	60	6	12,000 sq. ins.

THE RICHARDS PULSATOR JIG IS FULLY DESCRIBED IN BULLETIN NO. 1041.

DENVER ENGINEERING WORKS.



MANUFACTURERS

MINING, MILLING AND SMELTING MACHINERY.
ELECTRIC HOISTS.
CONCENTRATING TABLES.
CRUSHERS AND CRUSHING ROLLS.
RICHARDS JIGS AND CLASSIFIERS.
SAMPLE GRINDERS.
REVERBERATORY FURNACES.
SMELTING FURNACES.
MECHANICAL ROASTERS AND DRYERS.
ORE CARS, BUCKETS AND CAGES.
MINE TIMBER FRAMING MACHINES.
AUTOMATIC SAMPLERS.
STEEL WATER JACKETS.
TUBE MILLS.
STAMP MILLS.

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